# *Final Report*

A project under the Canada
New Brunswick Conservation
and Renewable Energy
Demonstration Program

# RIVER SOURCE HEAT PUMP

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CREDA PROJECT #105

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## Canada/New Brunswick Conservation and Renewable Energy Demonstration Program

The Conservation and Renewable Energy Demonstration Program Program is administered in New Brunswick by the Energy Secretariat and managed jointly with Energy, Mines and Resources Canada. The Program is designed to help demonstrate promising conservation and renewable energy technologies, to develop public awareness and understanding of these technologies, and to create employment in new or existing industries.

Through over 100 demonstration projects in New Brunswick, a wide variety of conservation and renewable energy technologies have proven to be technically sound and economically attractive. These demonstration projects should now provide a catalyst for commercialization and lead to widespread adoption of many of these proven technologies.

This final report is based on a project which was financially supported by the Energy Demonstration Program. For further information on other demonstration projects funded in New Brunswick under this program, contact:

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## Programme Canada/Nouveau-Brunswick de démonstration des économies d'énergie et des énergies renouvelables

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Un grand nombre de projets de démonstration se sont avérés à la fois techniquement réalisables et économiquement attrayants.

Le succès ainsi rencontré encourage la commercialisation des procédés les plus accessibles. Cela entraînerait certes l'adoption d'un grand nombre de ces techniques par les propriétaires de domiciles et par l'industrie privée.

Ce rapport final est basé sur un projet qui a reçu une aide financière du Programme de démonstration. Pour de plus amples renseignements, communiquez avec la:

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## D I S C L A I M E R

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## 1.0 EXECUTIVE SUMMARY

The purpose of this heat pump demonstration was to illustrate the ability of a river system in winter to provide house heat from relatively low water temperatures as an alternative to well systems. Conversely, to demonstrate the use of a river system in summer to provide swimming pool heat from relatively high water temperatures, again as an alternative to the more usual ground water system.

The major results of the demonstration were to establish that:

1) there is an abundance of heat available from water even at temperatures close to 32°F;

2) for heating a swimming pool in summer when river temperatures may exceed 75°F, the river system is far more efficient than a ground water system;

3) in summer, central air conditioning can be provided to a house at virtually no cost as incidental to heating the swimming pool.

## 1.0 RESUME

Ce projet de démonstration avait pour but d'illustrer les avantages d'une pompe thermique ayant la rivière comme source, comparativement aux systèmes de puits, pour chauffer les locaux d'une habitation résidentielle à l'aide d'une eau d'une température relativement basse. De la même façon, il sera possible de démontrer l'utilisation, en été, d'un tel système pour chauffer la piscine, la température de l'eau étant relativement élevée. Il s'agit une fois de plus d'une alternative au système généralement employé utilisant l'eau souterraine.

Les principaux résultats de cette démonstration sont les suivants:

1) il y a suffisamment de chaleur disponible même à une eau d'une température de 32°F;

2) lorsque les températures de la rivière dépassent 75°F, le système est beaucoup plus efficace que celui utilisant l'eau souterraine pour le chauffage d'une piscine;

3) en été, la climatisation centrale de la maison se fait à un coût minime, dû au chauffage de la piscine.

## 2.0 INTRODUCTION AND BACKGROUND

Water source heat pumps are by now fairly common but their efficiency has been adequately demonstrated only where the water source was a well. Wells are not always available in urban settings and their discharge water can also be a problem. By contrast, most urban centres border rivers, lakes or the sea, making the closed loop heat collector method of supplying a heat pump a sound alternative.

This demonstration project was initiated not only to heat a house but to heat a swimming pool, air condition and provide all domestic hot water. The proponent had earlier tried passive solar heating systems with limited success, attributable to the New Brunswick climate. Solar energy is very dependant on weather conditions. An abundant supply of energy is available on sunny days but during cloudy days and night time an alternate source of heat must be relied upon to supplement the solar system. On the other hand, the heat pump using limitless river heat functioned just as well at night as at any other time.

Clearly, systems vary, but it is reasonable to assume that the use of a heat pump system sourced by river water can provide space heating at an average cost which is 50% less than the cost of oil, gas or electricity. For this reason, future applications of this technology extend beyond individual household needs to motels, hotels, schools, office buildings, or other facilities sited on a large watercourse.

In the city of Fredericton, for example, the water at low level is about 20 feet deep in the main channel of the south side of the Saint John River. This channel from the site of the Westmorland Street Bridge to the Lord Beaverbrook Hotel exhibits a strong current (south side only) and good depth of water at the driest of times. In this particular area are located a number of key government buildings, the Lord Beaverbrook Hotel, Playhouse, Beaverbrook Art Gallery, Msgr. Boyd Family Centre and the York County Courthouse, all heated from one steam plant fired mainly by Bunker C fuel oil (one boiler uses No. 2 fuel oil). Total energy consumption for the area above mentioned is staggering. Significant energy savings could be achieved with river source heat pump systems.

Multi-building heating requirements are such that ground water source heat pumps would require large amounts of water which in turn would cause a strain or deplete the ground water supply. The amounts required are so great that only a large river such as the Saint John could supply enough heat. Theoretically, any river would freeze to the bottom if heat were continually extracted without a limit. This proponent believes that the amount of heat available is measurable based on average recorded flows.* Furthermore, the system need not necessarily replace or provide 100% of the heating load to be economically

* average flows Saint John River 1984 - 32,287 cubic ft./sec.
average flow Saint John River, Feb. 12 - 12,900 cubic ft./sec.
average flow Saint John River, May - 104,287 cubic ft./sec.

viable. The system might, for example, provide 100% of domestic hot water year round, 100% of air conditioning year round and from 50-100% of space heating depending on the severity of the winter. Back up oil and electric systems are already in place to provide any supplemental heat if required. Environmental changes relative to cooling the river could conceivably improve the river ecology. For example, low water situations during summer heat waves imperil the Atlantic salmon which like cold water and are susceptible to disease and high mortality in warmer water. Under these conditions heat extraction for domestic hot water and swimming pool heat might be of great benefit.

## 3.0 GENERAL DESCRIPTION OF THE DEMONSTRATION

This unit was a prototype to the extent that two heat exchangers were in use depending on the season:

1) A water-to-air exchanger to provide house heat.
2) A water-to-water heat exchanger to provide heat to an outdoor hot tub and swimming pool.

In the second mode, house air conditioning was supplied incidentally. Domestic hot water was provided continuously; that is, whenever the heat pump was operating water circulated through the thermostatically controlled hot water coil.

In the attached sketch, the house is shown on a promontory about 20 vertical feet above the collector coil in the river. Due to a siphon effect, the closed loop circulated with ease ten (10) gallons of water per minute up the embankment to the house. A three quarter (3/4) horsepower pump is sufficient to circulate the water in the loop. Originally one thousand (1,000) feet of plastic pipe was employed in the first year of operation, which has now been replaced by a two hundred (200) foot copper loop. Both plastic pipe and copper tubing had interior diameters of one and a quarter (1¼) inches. Water flowed to and from the hot tub and swimming pool by one (1) inch pvc plastic pipe capable of exchanging about fifteen (15) gallons of water per minute depending on pressure required. Amperage requirements were: Six (6) amps on the circulator pump, twenty-three (23) amps to run the compressor (heat pump) and approximately eight (8) amps to

run the blower for the air conditioning. The blower also circulates warm air in winter.

## 5.0 OBSERVATIONS DURING INSTALLATION AND MONITORING

Equipment used was manufactured in Moncton, N.B. by Glencar Industries Ltd. using a modified model G.C. - 050 HW with 50,000 BTU rating. Notwithstanding that Glencar is no longer in business it is clear that (1) water source heat pumps are similar from one manufacturer to the next, and that (2) observations and recommendations on improving design as noted in this report may be applied to any make of heat pump.

Some observations made during installation which deserve mention are:

1) try to locate the unit as close as practically possible to the electrical entrance. 'Start' amperages for these units are high even if the 'run' amperages are low. If the unit is replacing an oil system as here, the entrance itself may be limited. In this case the 1948 vintage sixty (60) amp entrance was inadequate and a two-hundred (200) amp. new entrance had to be installed. In assessing capital costs and practicability, make sure that the electrical entrance has sufficient excess capacity or be prepared to install a new entrance.

(2) "Stock" or off the shelf units usually do not come with a 'hard start' kit. 'Hard start' kits are readily available and can be added. In fact, if low water temperatures are going to be used, the unit design should incorporate 'hard start' features. This was a practical difficulty noted in this system. At standard ground water temperatures (approximately 47°F) the

compressor will start more easily than it will at a lower temperature such as 32°F.

(3) Lack of a T.X. or expansion valve leads to problems in getting the freon system to equalize. A T.X. valve regulates the condensation point in the evaporator coil. Systems designed to run on a constant 47°F ground water temperature require a constant condensation point in the coil. A practical difficulty encountered was the need for a T.X. valve which was later added because water temperatures varied widely between 32°F and 75°F. 'Stock' or shelf units using a constant 47°F heat source employ what is referred to as a 'cap and tube' system which is not appropriate as noted.

(4) Difficulty was experienced in making secure connections between couplings and the low pressure plastic pipe used for the heat collecting loop, even when double and triple clamped. Considering the level of existing technology and the availability of most minor plumbing fittings it was surprising that a reliable stainless worm gear type hose clamp was not readily available. The standard set by Tridon Clamps of Burlington, Ontario did not withstand any amount of torque without stripping. Once stripped the clamps looked the same but allowed leaking. These clamps, which are no doubt adequate for most everyday uses, were unsatisfactory particularly where water temperatures vary from 32°F to 75°F. Unfortunately, there was little else on the market, and muffler clamps which can withstand a good deal of tightening were used instead.

## 6.0 COST/BENEFIT ANALYSIS

### 6.1 Cost

Costs associated with this project and ensuing benefits were more or less as projected. That is, capital costs did not substantially exceed those in the proposal below:

| | |
|---|---|
| Heat Pump with 2nd heat exchanger to pool and air conditioning coil | $5,800.00 |
| Pipe for closed loop collector and circulator pumps | 900.00 |
| Labour re: electrical, plumbing, etc. | 800.00 |
| Anti-freeze for loop, trenching etc. | 500.00 |
| | $8,000.00 |

The $8,000.00 figure does not include monitoring costs or extra costs associated with the project which were not anticipated in the proposal for funding. These were:

| | |
|---|---|
| 10 KW. duct heater for emergency back up | $ 350.00 |
| Additional ductwork | 200.00 |
| Valve over system to well for alternate heat source/emergency back up | 600.00 |
| Copper pipe loop to replace plastic pipe | 400.00 |
| Upgrading electrical entrance | 1,000.00 |
| | $2,550.00 |

None of the last mentioned costs ($2550) were essential to the demonstration project but were opted for and funded by the proponent.

The proponent received $5,000 of the $8,000 capital cost. The remainder, designated for demonstration and dissemination of project information, was not administered by the proponent. The funds were granted under the Conservation and Renewable Energy Demonstration Program administered by Energy, Mines and Resources Canada and the New Brunswick Energy Secretariat.

## 6.2 Benefit

Precise monitoring of electrical consumption was made difficult by (a) a mid-winter breakdown of the plastic loop heat collector (b) use of 3.5 kW of electric baseboard heat at times in the occupied rooms. The additional heat was only used at times for increased comfort and convenience, but it caused some estimations to be made for electrical consumption.

The oil burning system was removed. Heat pump Coefficients of Performance (C.O.P.'s) varied from a low of 1.6 with 32°F water and 4.0 using 75°F water to obtain 85°F water in the swimming pool. An average C.O.P. of 2.0 was obtained for the house during the heating season October 1 to May 1 with an average C.O.P. of 2.8 between May 1 and October 1.

Owner benefit from this system when used as a source of swimming pool heat is overwhelming, considering that the quantities of heat required are so great it would be foolish to attempt 100% heating with electricity, gas or oil. A river source heat pump system seems to be the only practical heat source available for this purpose aside from solar.

## 7.0 CONCLUSIONS

This project demonstrated that there was plenty of heat available from river water at approximately 32°F. Lack of success at lower temperatures using air as a heat source has lead to a bias, it was believed, against using water colder than ordinary ground water. More recent developments, notably in Finland, are now demonstrating that the latent heat of fusion associated with freezing water offers a tremendous potential in new heat pump technology.

Unquestionably, the stated objectives of this demonstration project were met and practical information on a potential heat source for consumers living alongside rivers has been gathered.

Some specific advantages of a closed loop river sourced system over a ground water sourced system were discovered during the project.

1) Discharge water which can be both a practical problem and an environmental problem was not an issue using the closed loop. Cooling effect on the river was inconsequential because of its size and also in this case because the water had been warmed just upriver by a large hydroelectric plant. Thus, the environmental effect was actually to lessen the changes imposed by the hydroelectric facility.

2) A common problem affecting ground water discharge systems is accumulated scaling in the coils caused by minerals which precipitate from the volumes of water being used. The

closed loop system eliminates this problem.

3) Heat available from water near the freezing point is still substantial. Because it is filled with antifreeze, the closed loop method will enable heat extraction to well below 32°F. In this project the return side of the system was often found to be 26-27°F. Neither will the closed loop ice up as long as the river is moving over the loop. Icing of the loop would be a problem if the heat source was a pond or lake with little water movement.

4) C.O.P.'s available at 32°F± though lower than that from well water at 47°F can be compensated somewhat by maximizing flow through the loop. In this case flows greater than the 10 gpm. required for a normal well water discharge system were used at times.

5) Application as a source of heat for a swimming pool was unbeatable. It is doubtful that there is any better method or source of heat. River water at 75°F in July is so much warmer than ground water that an outdoor hot-tub, in addition to the swimming pool, added in the second summer of operation of the system was easily kept at 105°F. The proponents were surprised that heat pump systems such as theirs have not become universal by now for motels or outdoor municipal pools.

6) Incidental to the swimming pool heat was the production of all domestic hot water and a central air conditioning system.

The air conditioning did not involve an additional refrigeration coil. Only a radiator (heat exchanger) through which the cooled side of the loop was being returned to the river was used. This exchanger was placed in the return side of the plenum (in winter the hot air return side), and the hot air from the house passed through the plenum returning cooled air to the house. In actual fact, the hot house air helped to warm the loop requiring even less heat pick up from the river.

## 8.0 RECOMMENDATIONS

Replicators of this system should keep in mind the following recommendations which are based on the proponent's experience:

1) Make sure a T.X. (expansion bulb) system is used in the evaporator coil design as opposed to a fixed cap and tube system. This is because of widely fluctuating water temperatures from one season to the next.

2) Use a minimum of 125 p.s.i. plastic pipe, if plastic pipe is used at all, and copper pipe, if at all possible, in building the heat collecting loop. Do not use copper if the water source is not moving, such as when a pond or lake is the heat source. In these situations the collector will ice up if made of copper but probably will not if made of plastic, since the heat transfer will be more gradual. In this project, original plastic tubing failed and was then replaced with copper. There is nothing inherently wrong with using plastic pipe, and it is quite inexpensive, less than 50¢/ft. The reason it was replaced with copper was that the 75 p.s.i. pipe used fractured due to mishandling and the elements. Had 125 p.s.i. been used, there would not have been any problem.

3) Incorporate a "hard start" kit in the heat pump design. This, again, is to compensate for widely fluctuating water temperatures which might cause the compressor difficulty in starting.

4) Use ordinary windshield washer fluid in the loop instead of radiator anti-freeze. Since the loop is never 'heating' rather it is being cooled, there is no reason to believe windshield washer is not just as good as more expensive car anti-freeze. Heat coefficients of windshield washer and anti-freeze were checked and found to be lower than water but roughly equal to each other.

5) Seek out couplings and fasteners (clamps) which are superior to ordinary plastic fittings and Tridon clamps. Avoid more couplings than necessary. For example, plastic 1¼ or 1½ in. pipe comes in 100, 300, and 1000 foot lengths. Avoid using multiples of 100 and 300. A similar project to this one will require from 700-1000 feet of plastic pipe. Plastic pipe 1¼ inch diameter is recommended over the more common 1½ inch diameter, because it is much easier to work with and does the job as well. Two hundred (200) feet of 1¼ inch flexible copper is roughly equivalent to 1000 feet of plastic in terms of heat transfer.

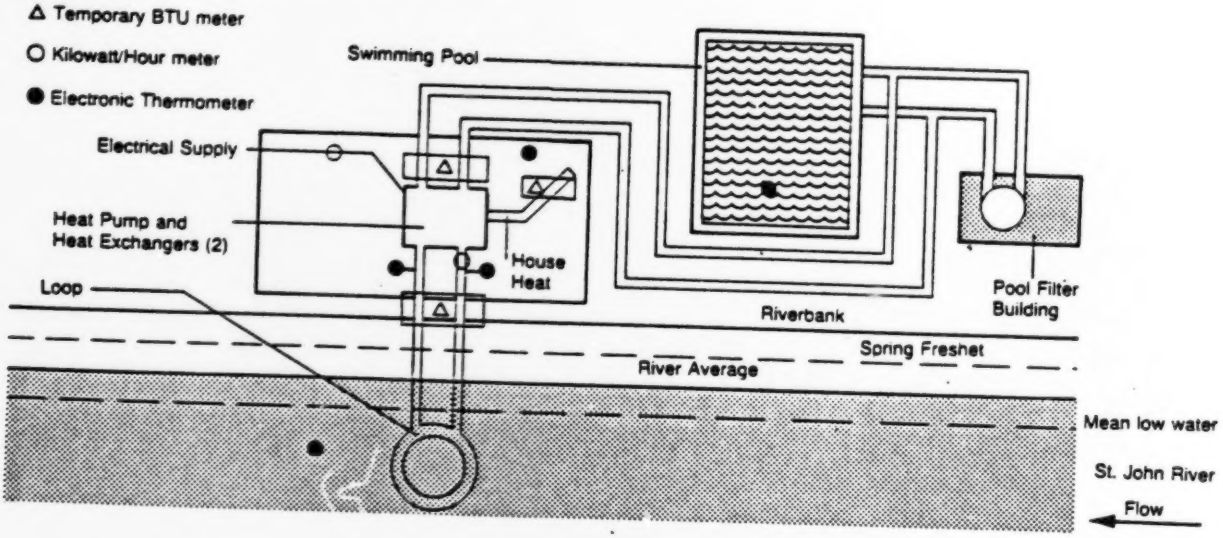
## 9.0 SUPPORTING MATERIAL

1) Successors to Glencar Ltd., Moncton.

A successor company has been formed by GLEN KAYE known as "Maritime Geothermal Energy Systems Ltd.", Petitcodiac, N.B., E0A 2H0; Phone (506) 756-8135. Similar in design to the Glencar Ltd. unit, the Maritime Geothermal units are smaller and technically superior.

2) Schematic design of unit attached.

**Schematic Diagram:**



# Glencar Industries Ltd.

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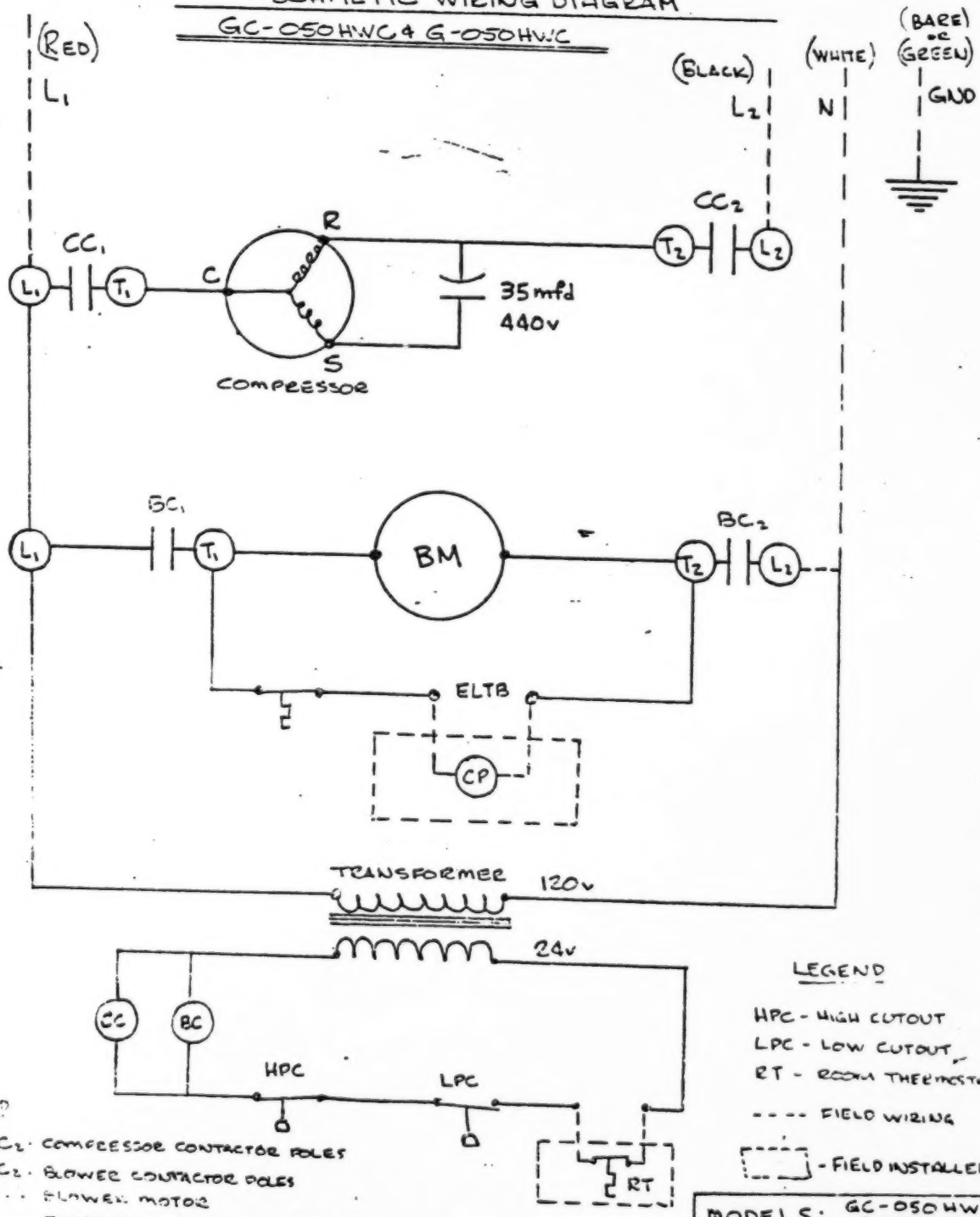
## SCHMETIC WIRING DIAGRAM

### GC-050HWC & G-050HWC




LEGEND

HPC - HIGH CUTOUT
LPC - LOW CUTOUT
RT - ROOM THERMOSTAT
---- FIELD WIRING
[ ] - FIELD INSTALLED.

LEGEND

CC1, CC2 - COMPRESSOR CONTACTOR POLES
BC1, BC2 - BLOWER CONTACTOR POLES
BM ----- BLOWER MOTOR
ELTB ---- EXTERNAL LOAD TERMINAL BLOCK
CC ----- COMPRESSOR CONTACTOR

| MODELS: | GC-050HWC G-050HWC |
|---|---|
| GLENCAR | JAN 8/82 |